Freight Analysis Framework (FAF) and the Waterborne Commerce of the United States (WCUS)

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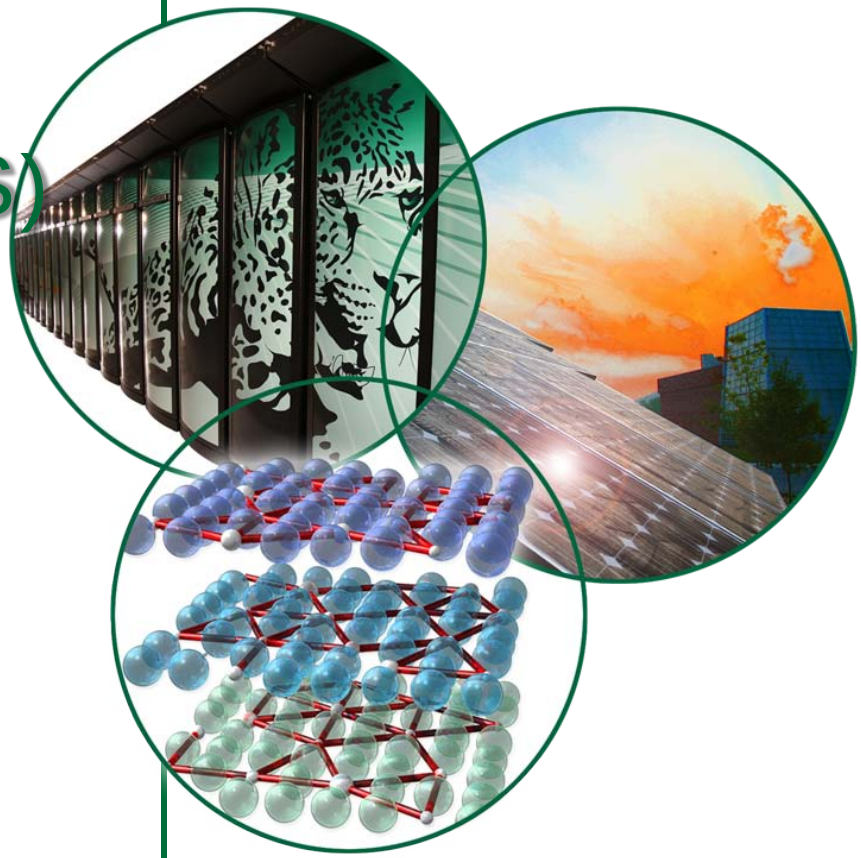

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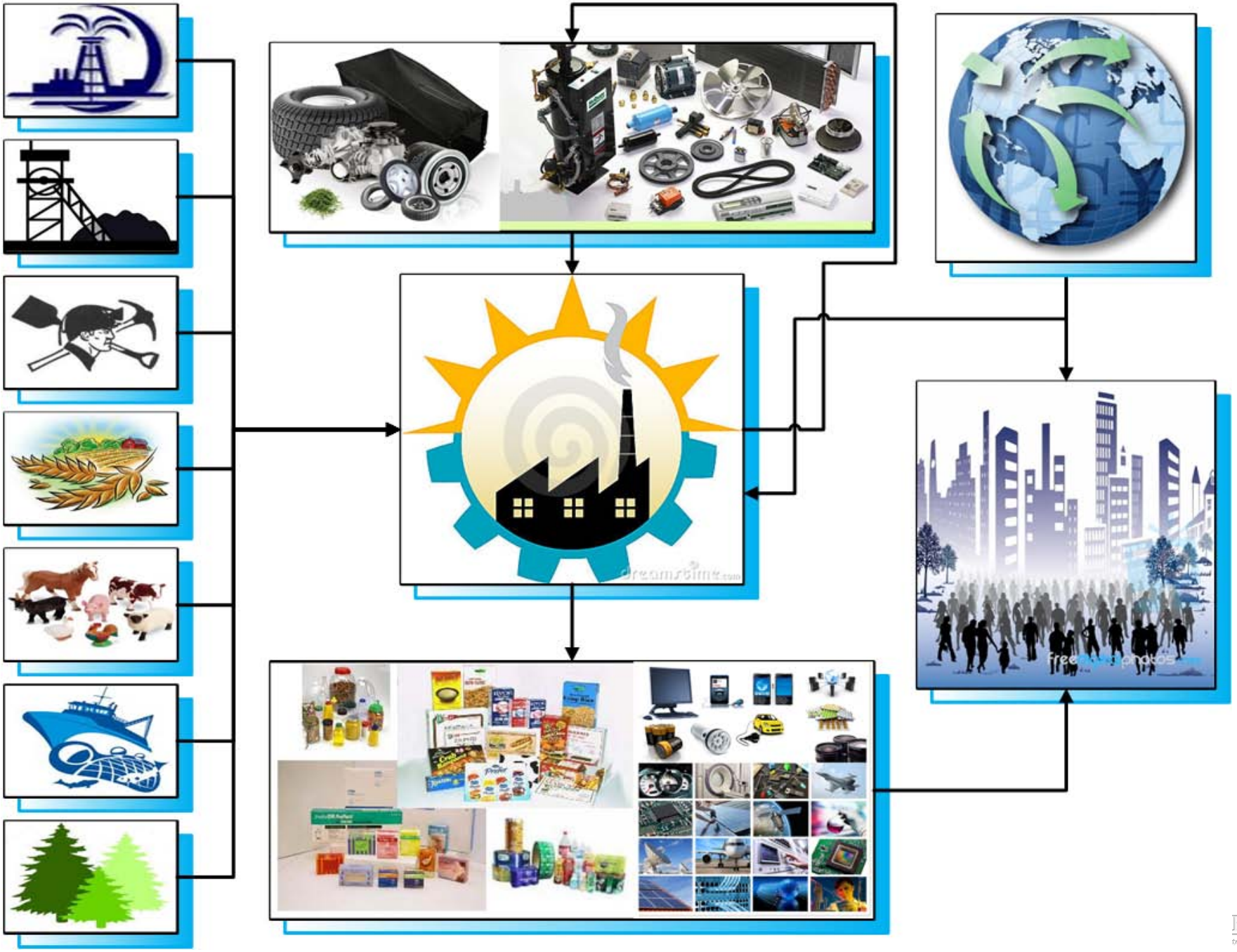


Freight Analysis Framework (FAF)

- A data program sponsored and maintained by the Office of Freight Management and Operations, Federal Highway Administration (FHWA), U.S. Department of Transportation. Currently in its third generation (i.e., FAF^3).

- Provides a comprehensive picture of freight movement among states and major metropolitan areas by all modes of transportation.

FAF provides data for freight demand models

- A data matrix with tonnage and value of regional freight flows by commodity and mode for base year 2007, with forecasts to 2040, and reprocessed and annual provisional updates
- Shipments include domestic, exported, and imported freight
- *8 Domestic modes*
  - truck, rail, water, air, multiple modes and mail, pipeline, other & unknown, and no domestic mode
- *7 Foreign modes*
- *43 Commodity classes*
  - *2-digit Standard Classification of Transportation Goods; SCTG codes*
- Major source: 2007 Commodity Flow Survey
- Truck flow assignment for 2007 and 2040

Industry Sectors

212. Mining (Except Oil and Gas)

311. Food Manufacturing

312. Beverage and Tobacco Product

313. Textile Mills

314. Textile Product Mills

315. Apparel

316. Leather and Allied Product

321. Wood Product

322. Paper

323. Printing and Related Support Activities

324. Petroleum and Coal Products

325. Chemical

326. Plastics and Rubber Products

327. Nonmetallic Mineral Product

331. Primary Metal

332. Fabricated Metal Product

333. Machinery

334. Computer and Electronic Product

335. Electrical Equipment, Appliance, and Component

336. Transportation Equipment

337. Furniture and Related Product

339. Miscellaneous

421/423. Durable Goods

422/424. Nondurable Goods

454. Electronic Shopping and Mail-Order Houses, and Fuel Dealers

493. Warehousing and Storage

551. Corporate, Subsidiary, and Regional Managing Offices

Model Specification

$$log(y_{it}) = \beta_{0,t} + \beta_{1,t}\, log(x_{it}) + u_{it}$$

$\beta_{0,t}$ and $\beta_{1,t}$ are the intercept and slop parameters, respectively; u is the stochastic error term; i denotes the geography area; t denotes the year.

Variables

PRODUCTION

y = CFS Shipment Tons/Values (thousands/$millions)
x = CBP Annual Payroll ($millions)

ATTRACTION

y = CFS Received Tons/Value (thousands/$millions)
x = CBP Share of Annual Payroll ($millions)

Data Sources

Estimate a nationwide production and attraction models for U.S. domestic trade of goods.

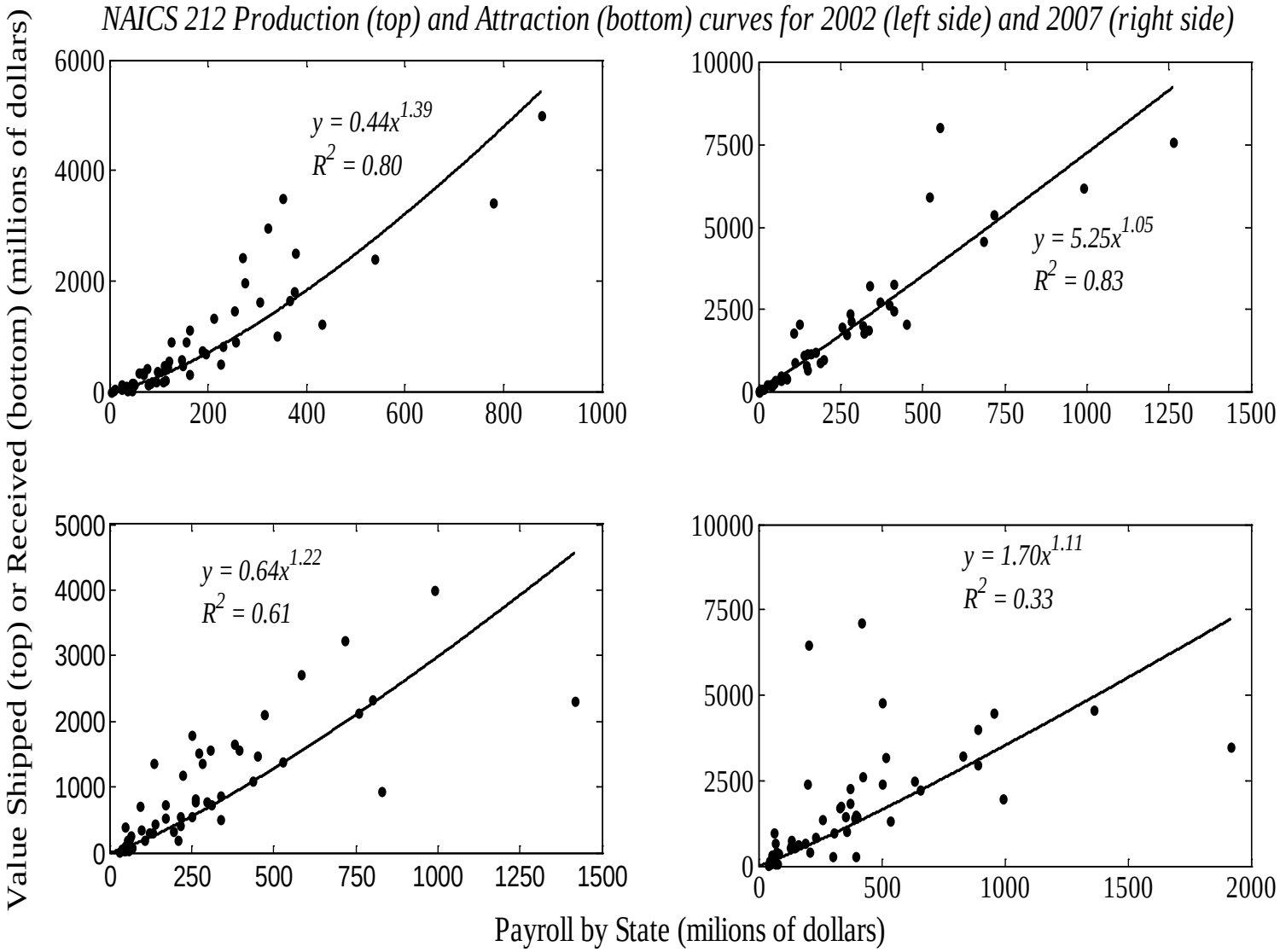
- ***Data***

  - Commodity Flow Survey (CFS) data set from U.S. Census Bureau with movement of goods between states by 27 industry sectors

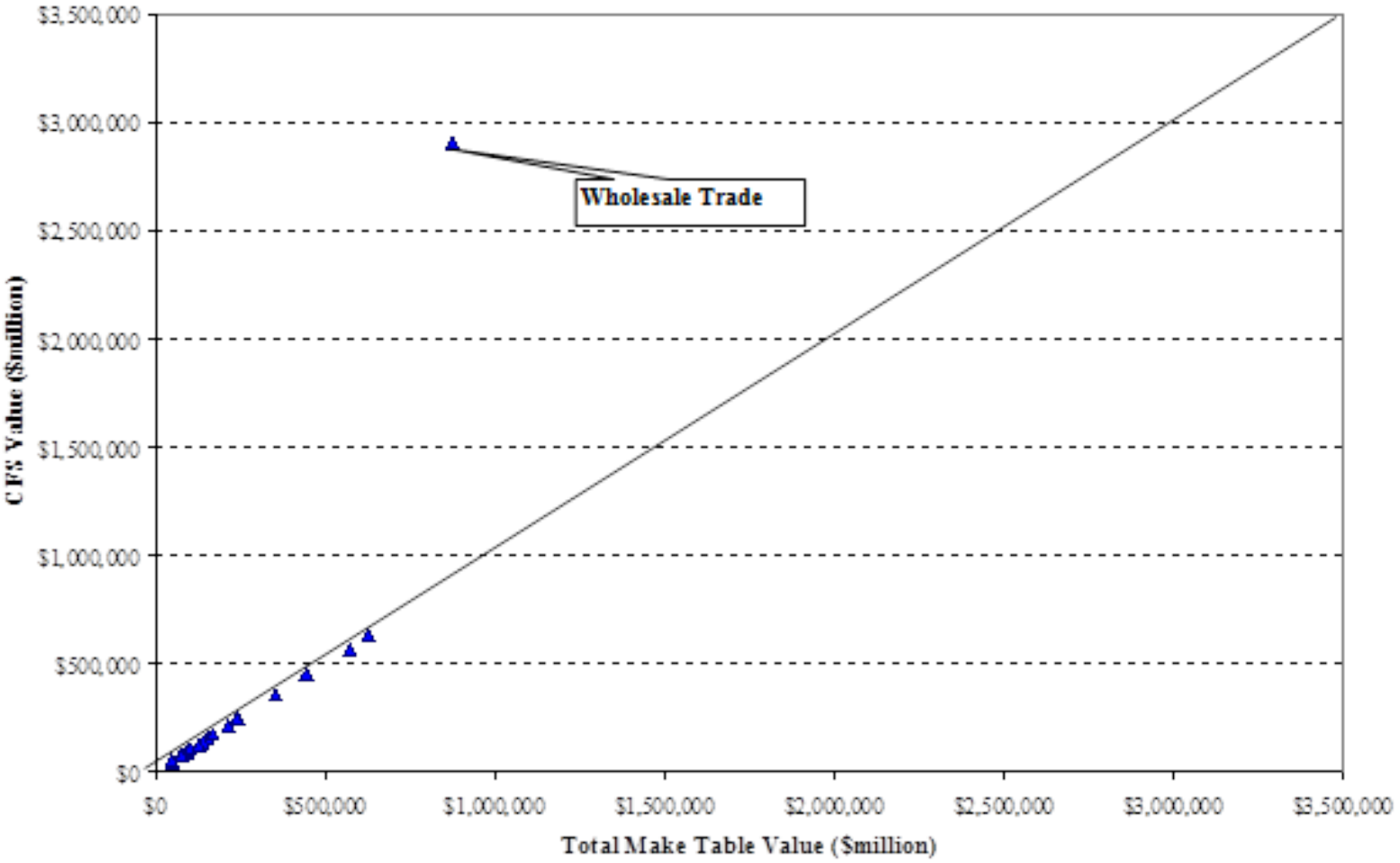
  - County Business Pattern (CBP) of the U.S. Census which contains the state payroll by industry sector

  - Annual input-output accounts). With the Input-Output tables it is possible to estimate the quantity of commodities, measured in value, produced by one industry sector necessary to produce outputs for another industry sector

Production and Attraction Curves for NAICS 212

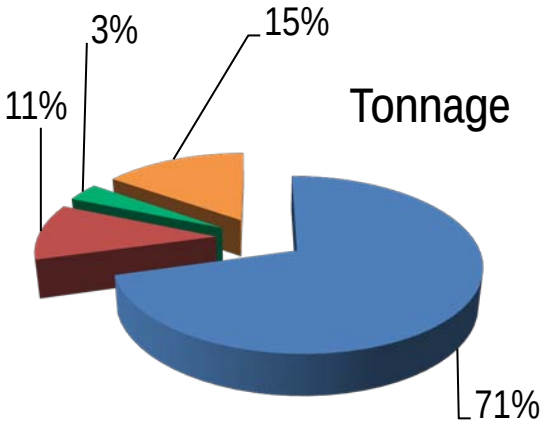


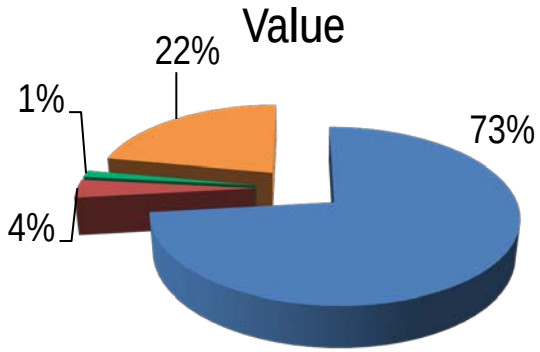
CFS Values vs. Make Values from Input/Output Accounts

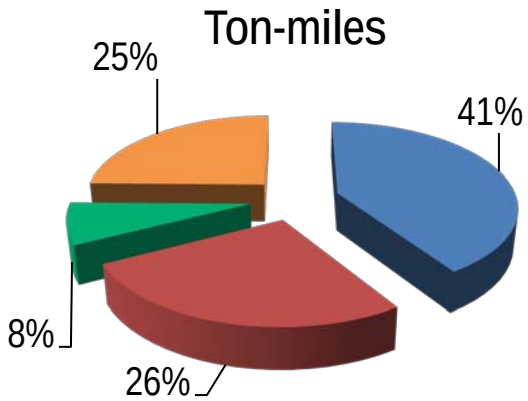


Mode Share in 2007

National share of by mode (including domestics, imports, and exports) based on FAF data

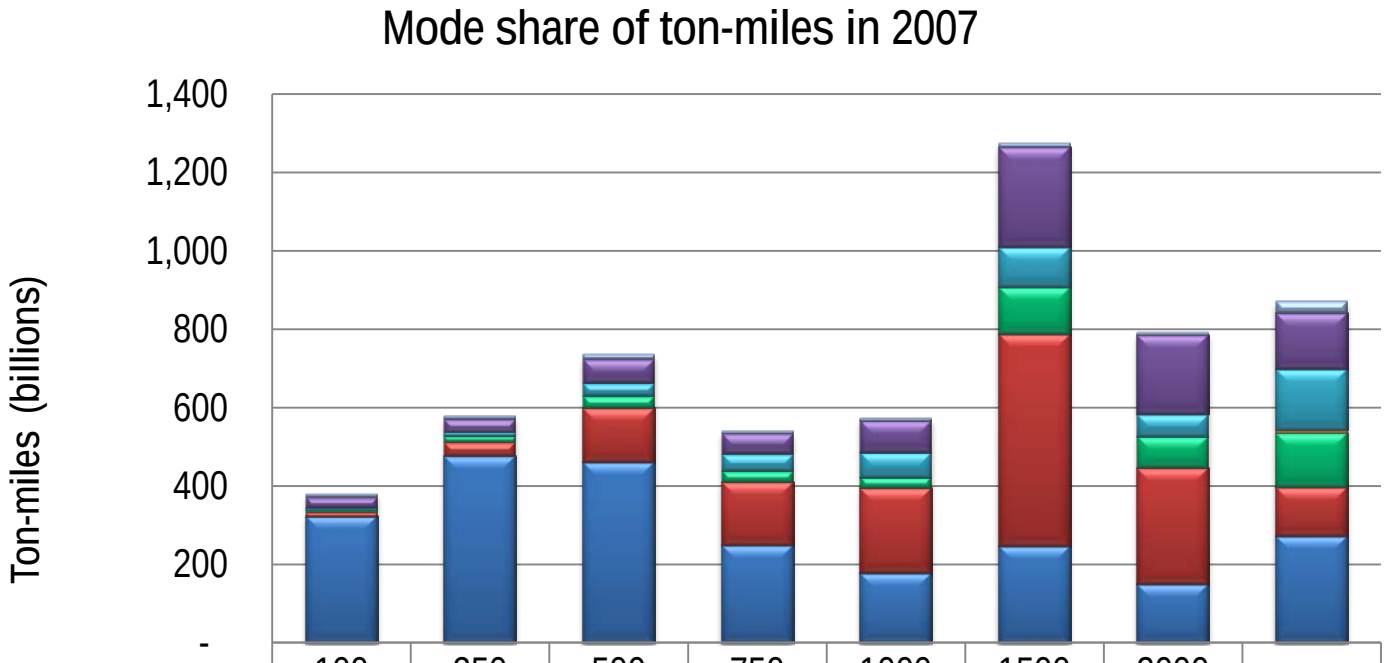






	Value/ Weight ($/lb)	Value/ Ton-miles ($)
Truck	0.46	5.19
Rail	0.14	0.38
Water	0.16	0.47
Others	0.64	2.59

Freight Activity by Distance



	100	250	500	750	1000	1500	2000	over
other&unknown	8	9	10	6	7	10	6	31
pipeline	27	32	62	52	82	255	203	143
multiple	4	11	33	44	63	102	57	156
air	0	0	0	0	0	1	1	7
water	7	15	30	29	28	120	81	139
rail	12	36	138	161	215	540	297	124
truck	321	476	460	248	178	247	148	272

FAF and WCUS Estimated Ton-miles

WCUS: Loading–unloading Points

ton-miles = 553 – 46 (U.S. Territories) – 1.6 (Intra-port) = 506 billions

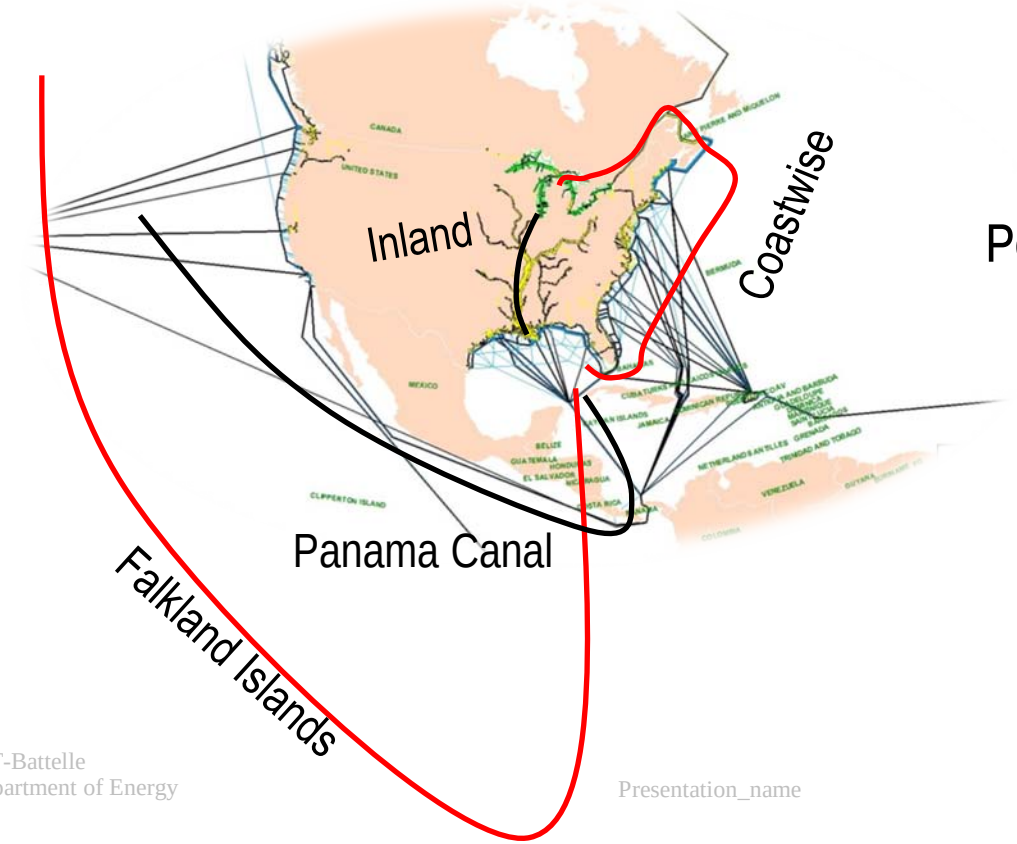
FAF3.3 : O-D Weighted distance * O-D Tonnage

Ton-miles by water only = 450 billions

Ton-mile by multiple modes = 469 billions (~24% is water)

Ton-mile by water = 564billions

Difference about 10%



Possible discrepancies:

-Geographic

-Commodity

-Dredging

Examples of Mode-choice Models

1. Logit Model

- Log Odds

$$\log(\pi_{ij} / \pi_{ik}) = \alpha_{ij} + \beta_{ij} d + \varepsilon_{ij}$$

i – industry

j – mode alternative

k – reference mode

d – great circle distance between states

- Model Elasticity

$$E_{ij} = \left[\beta_{ij} - \sum_{h} \pi_{ih} \beta_{ih} \right] d \qquad \textit{Where:} \quad \sum_{h} \pi_{ih} = 1$$

Percent change in the choice probability for a 1% change in the great circle distance (GCD)

Logit Model Example (cont.)

- **Parameters calibrated using 2007 CFS data**

Parameters	*Rail*	*Water*	*Air*	*Multiple*
GCD	0.00314	0.00154	0.00365	0.00276
Manufacture	-3.340	-3.394	-9.384	-3.585
Mining	-1.519	-3.875	-18.739	-3.333
Whole sale	-4.466	-6.758	-10.464	-3.766
Transport	-5.882	-4.831	-9.657	-4.985
Retail	-6.409	-10.018	-9.059	-3.301

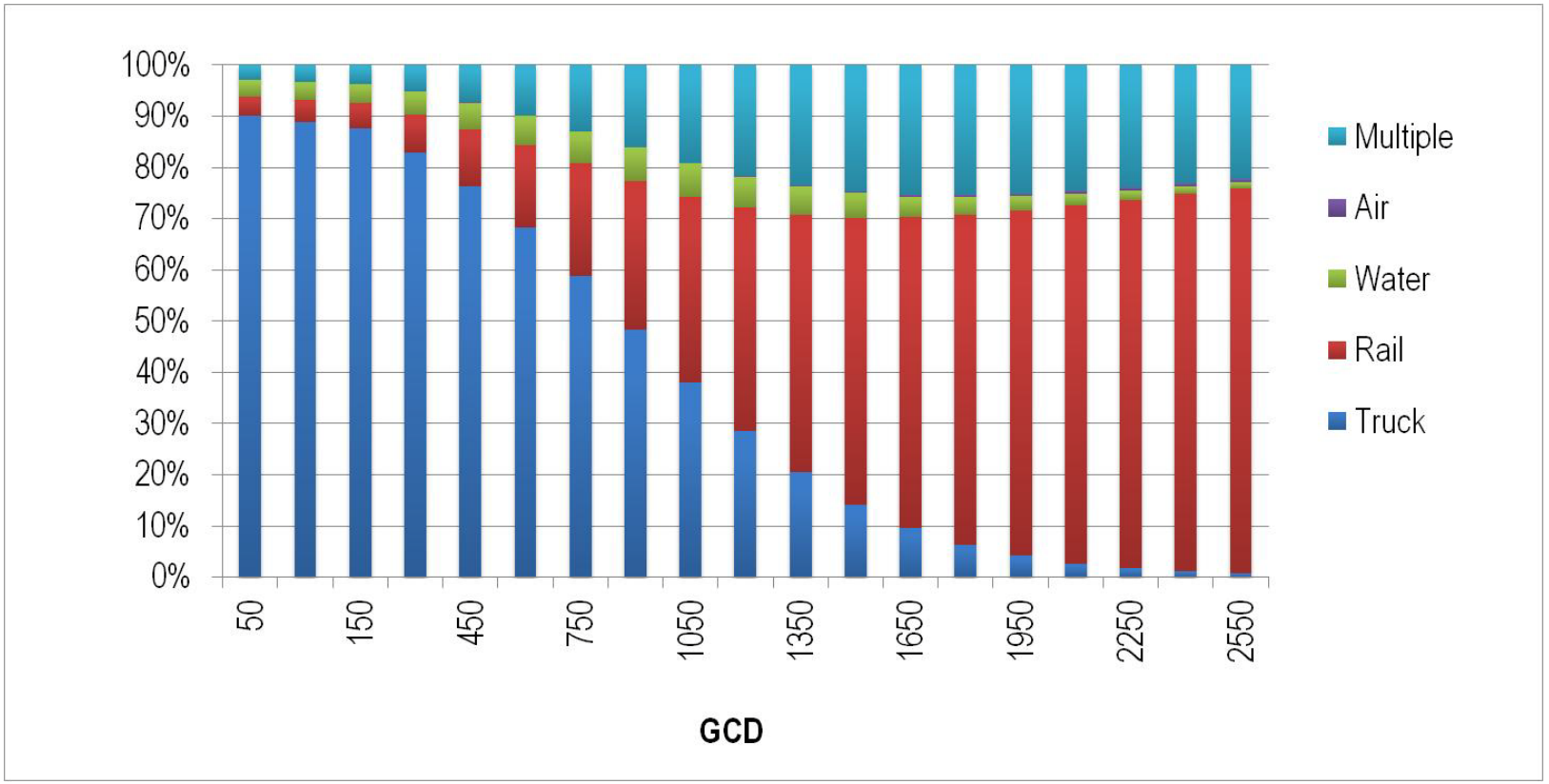
- **Model for manufacturing and rail**

$$\log(\pi_{rail} / \pi_{truck}) = -3.34 + 0.00314d + \varepsilon_{rail}$$

Compared to the odds by truck, a unit of ton is less likely to be moved by rail, but it is more likely for higher distances between states.

Logit Model Example (cont.)

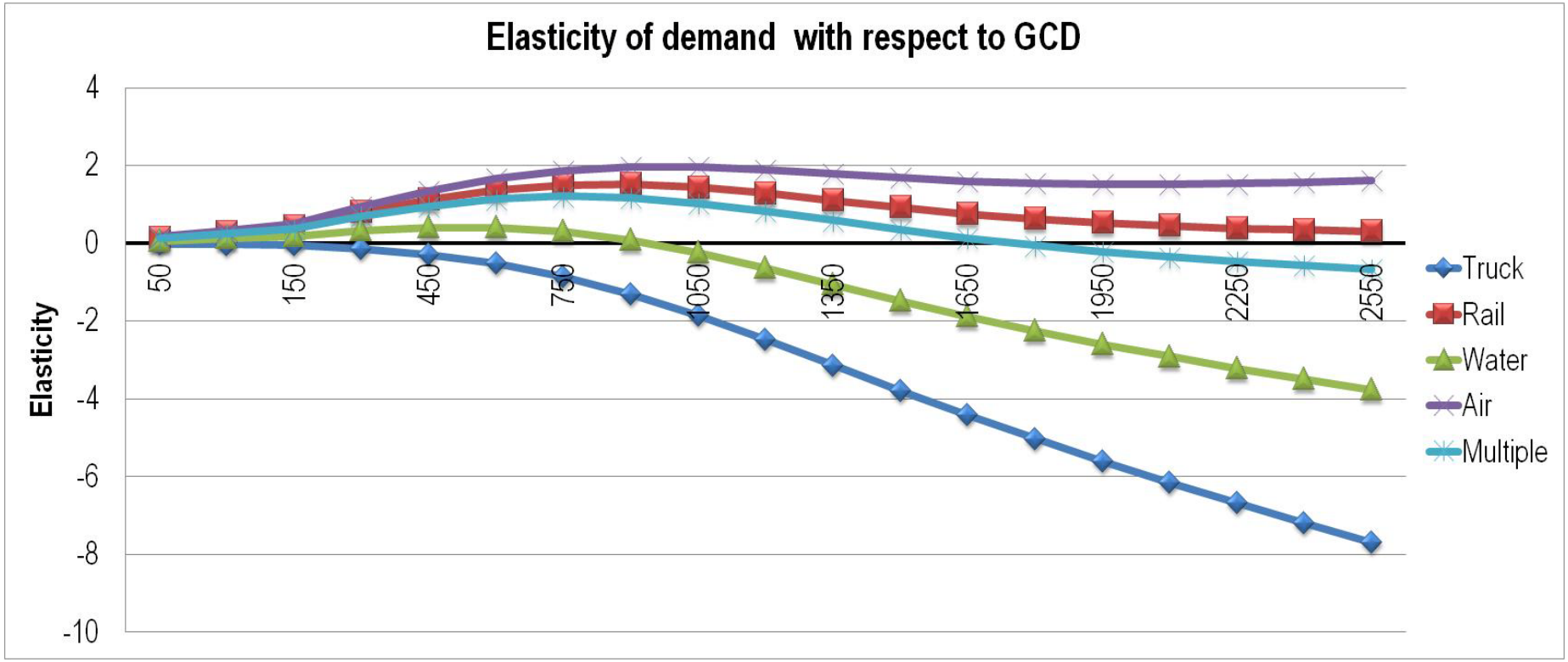
- **Mode Share for the Manufacturing Sector**



Water movements are more likely to happen around 1000 miles

Logit Model Example (cont.)

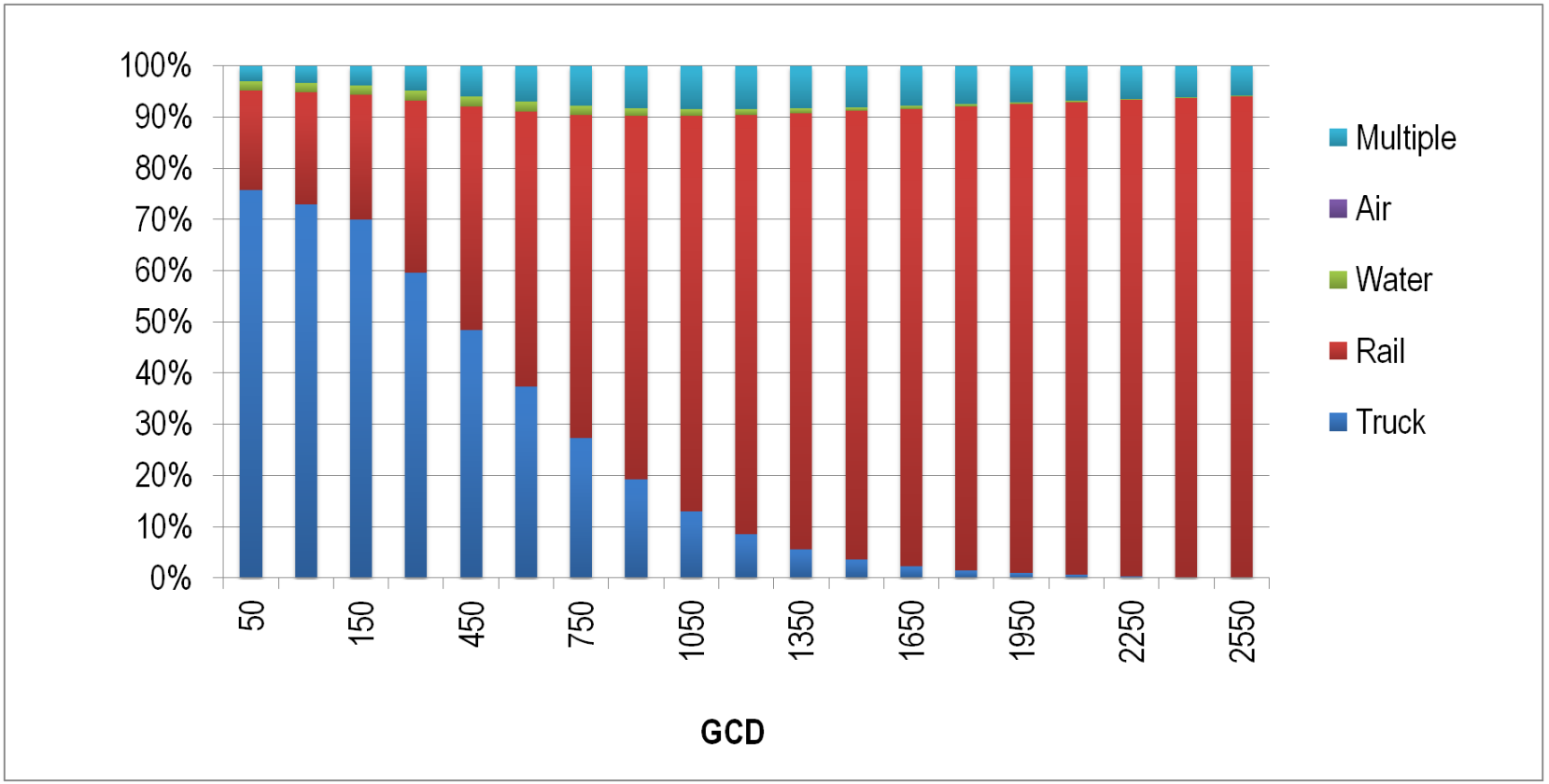
- **Elasticity of demand for manufactured goods with respect to GCD**



Elasticity for water is positive until the distance of about 1000 miles, where the likelihood for water movements is maximum. Notice the elasticity for truck drops quickly to negative values.

Logit Model Example (cont.)

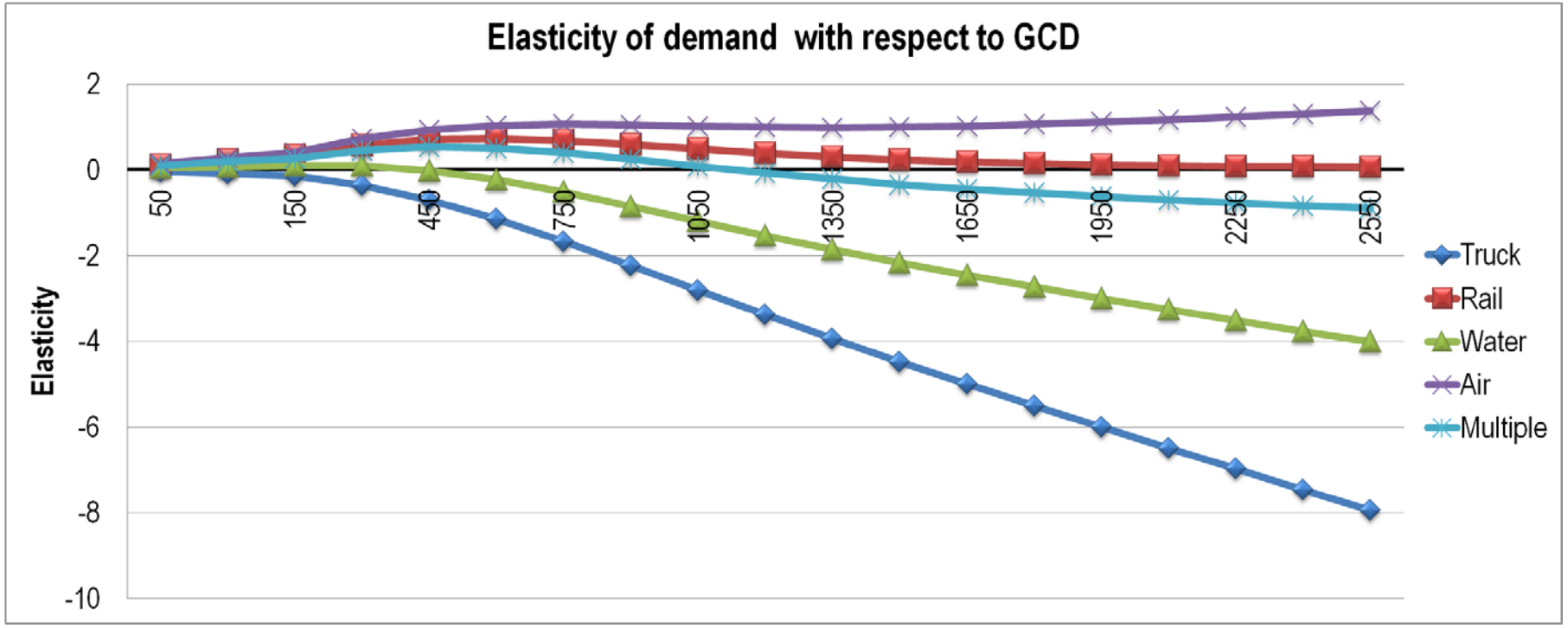
- **Mode Share for the Mining Sector**



Water movements are more likely to happen around 450 miles, in comparison with other modes. Rail share is dominant for distances over 450 miles

Logit Model Example (cont.)

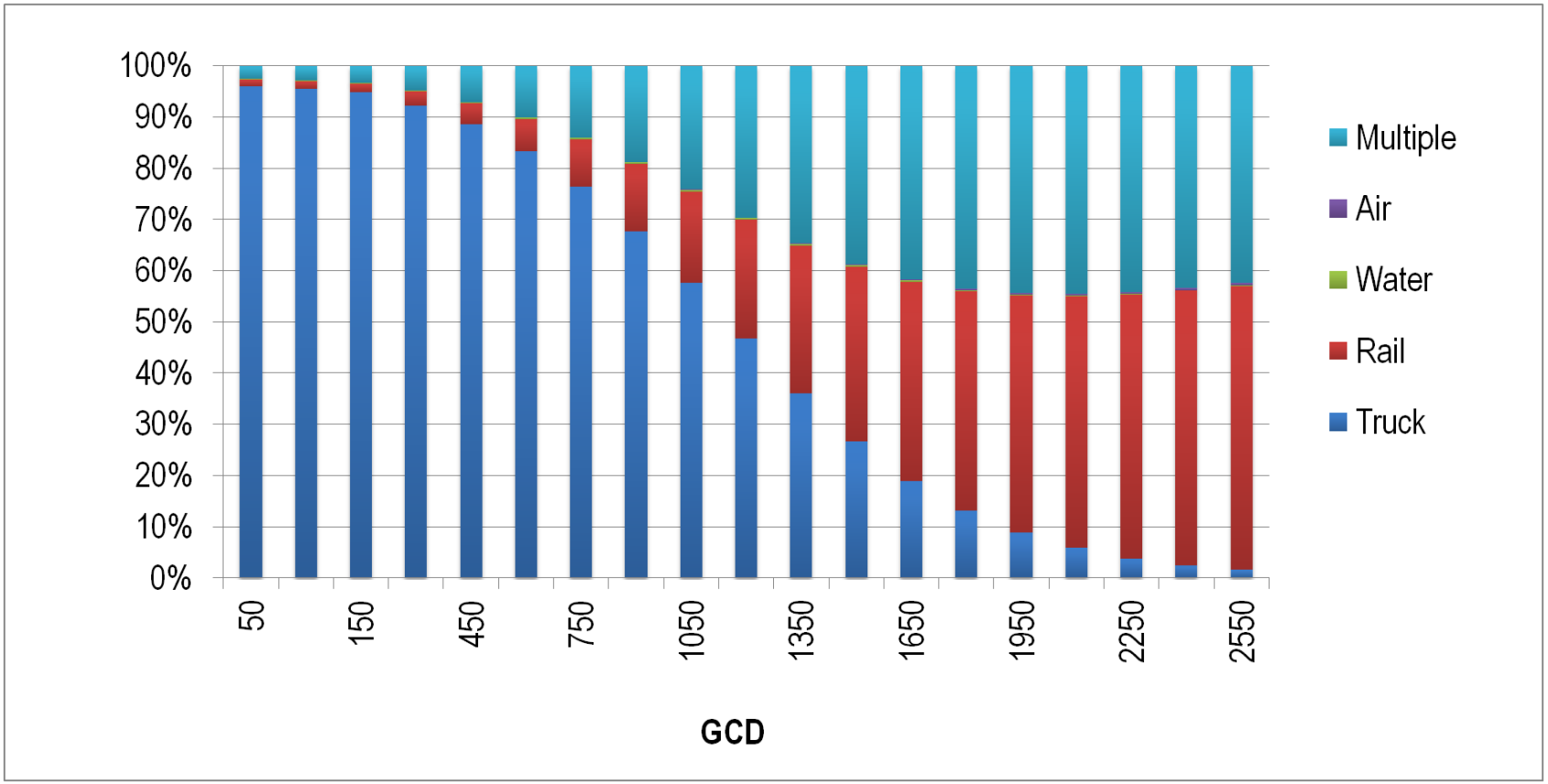
- **Elasticity of demand for Mining with respect to GCD**



Elasticity for water probability is positive until the distance of about 450 miles, where the relative likelihood for water movements is maximum.

Logit Model Example (cont.)

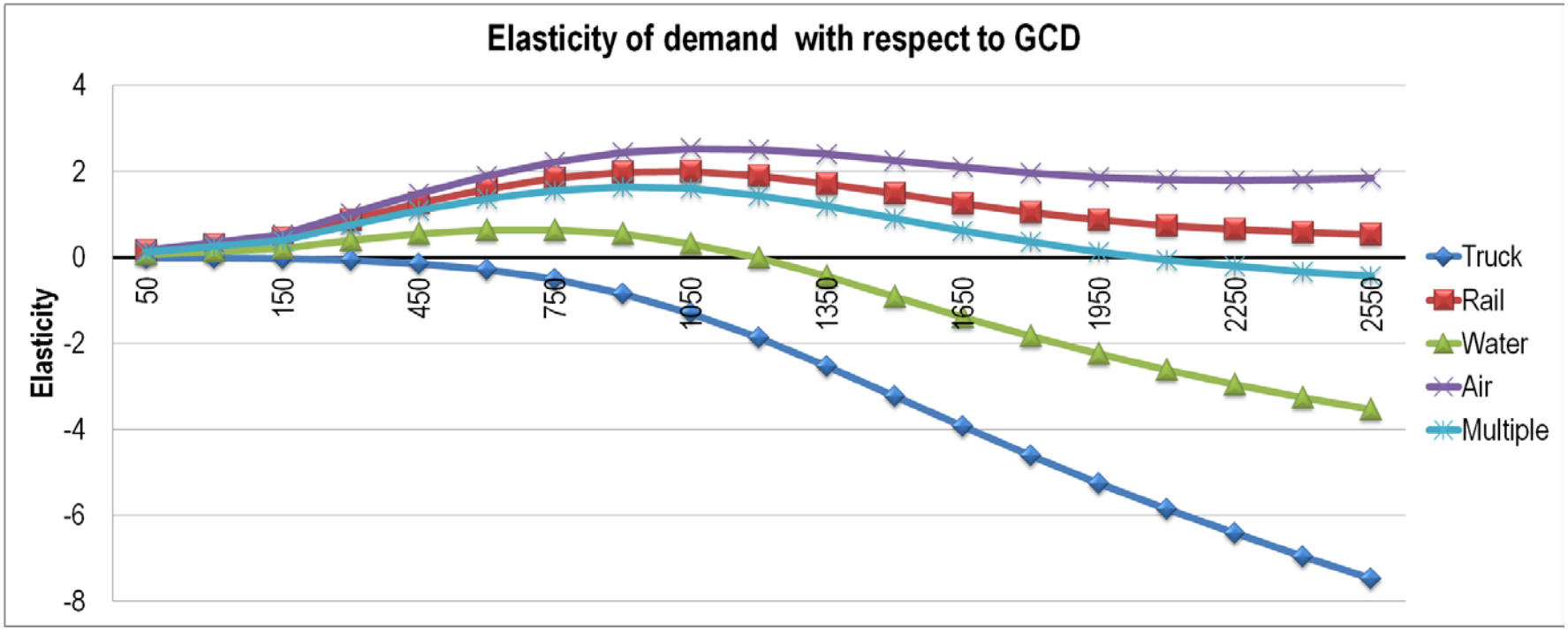
- **Mode Share for the Wholesale Sector**



Water movements are very rare compared to the other modes.

Logit Model Example (cont.)

- **Elasticity of demand for Wholesale with respect to GCD**



Elasticity for water probability is positive until the distance of about 1200 miles, where the relative likelihood for water movements is maximum.

2. Logit Model with Attributes of The Mode Service

- **Choice Probabilities**

$$\pi_{ij} = \frac{\exp(\alpha_{ij} + \mathbf{X_{ij}\beta_{ij}})}{\sum_{h} \exp(\alpha_{ih} + \mathbf{X_{ih}\beta_{ih}})}$$

X_{ij} – characteristics of the mode service: capacity, transportations costs, travel time, reliability, type of service, etc.

a_{ij} – industry i specific preference for mode j

Example of Logit Model (with attributes of mode services)

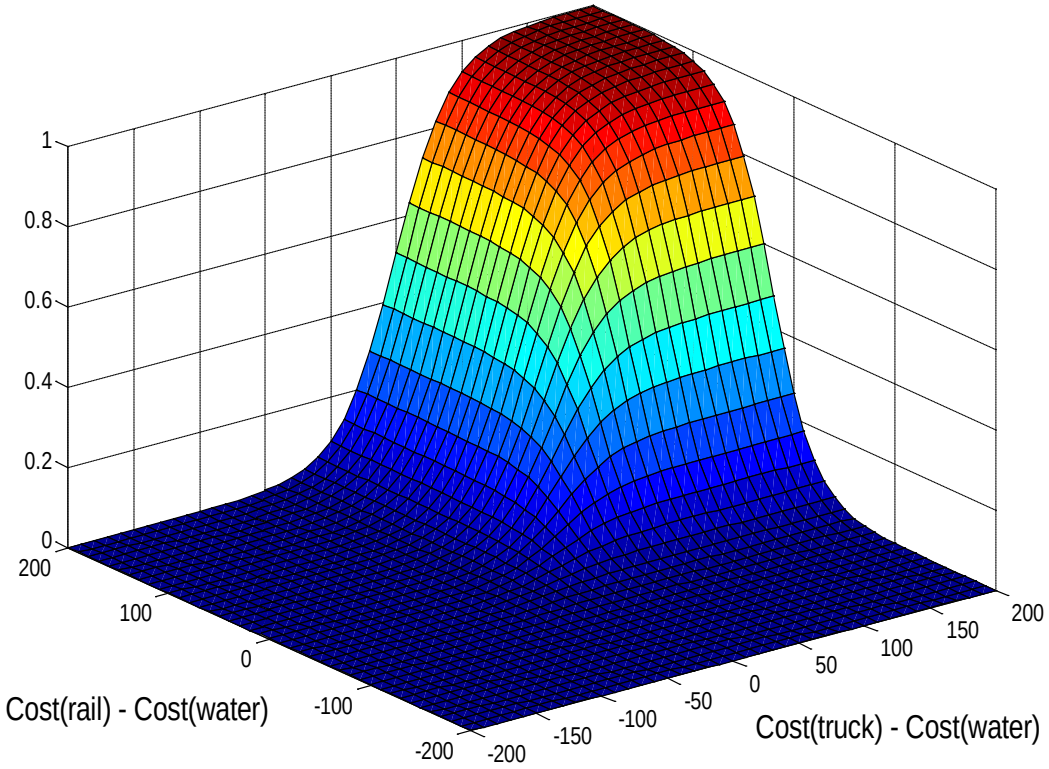
- **Model for Manufacturing**

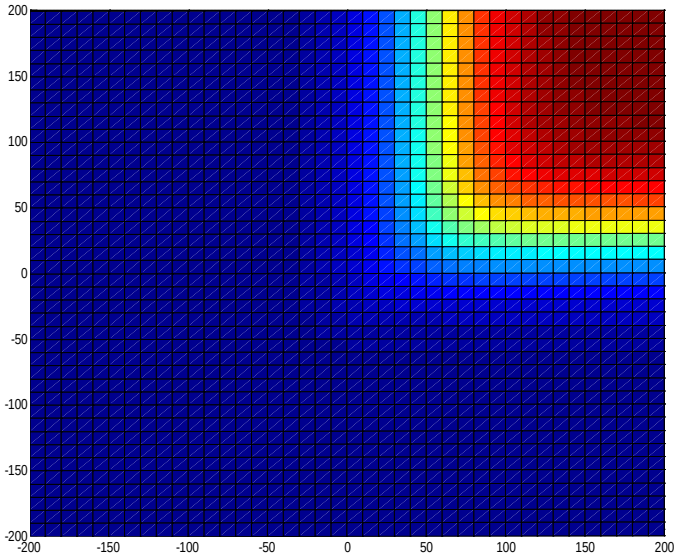
$$\pi_{j/od} = \frac{\exp(\alpha_j - \mathbf{0.0482}\, c_{j/od} + \mathbf{0.25}\, n_{j/od})}{\sum_h \exp(\alpha_h - \mathbf{0.0482}\, c_{h/od} + \mathbf{0.25}\, n_{h/od})}$$

$C_{j/od}$ *– transportation cost (loading-unloading, fixed cost, time dependent cost, distance dependent cost)*

- *$n_{j/od}$ – network infrastructure: n_j = log(# of county pairs in o-d served by mode j)*
- *Choice set* **H =** {Truck, Rail, Water}

Water Likelihoods for Manufacturing





$$\pi_{w/od} = \frac{1}{1 + \sum_{h \neq w} \exp(\alpha_h - \alpha_w - \mathbf{0.0482}\,(c_{h/od} - c_{w/od}))}$$

Remarks

- Model will not overestimate freight traffic
- Spatial equilibrium model
- The models presented are only examples of the mode-choice calibrated with the aggregated data from CFS
- With more data on the mode service characteristics, socio-economic attributes of the geographic zones, other models can be specified so that the potential for modal shifting can be better analyzed

Evaluate National Transportation Policies (long term)

- Public Policies can affect freight transportation system

  e.g., safety, security, land use, environmental, etc.

- Individual public policies can affect freight transportation system

  Hours of Service (HOS) rules for truck drivers or train operators, speed limits, restrictions on locomotive, size and weight, level of investment, fee/toll, etc.

- National programs in favor of water transportation:
  - Energy Act
  - America‘s Marine Highway Program

Evaluate National Transportation Policies (short-term)

- Waiver of the harbor maintenance tax for some non-bulk freight
- Equal customs notification requirements for waterborne container shipments from Canada via the Great Lakes Saint Lawrence Seaway System relative to land-based shipments of the same containers
- Implementation of shipper tax credits linked to the value of public benefits associated with the decision to select water transportation
- implementation of investment tax credits and accelerated depreciation for vessel and port equipment purchases